HUC 11010008 – Current River
Water body ID: 2668
Section 303(d) Listing: *Escherichia coli*

Total Maximum Daily Load

for

Ashley Creek
Texas and Dent Counties

303(d) Listing: *Escherichia coli* Bacteria

Submitted: October 28, 2024
Approved: December 16, 2024

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for Ashley Creek
303(d) Listing: *Escherichia coli (E. coli)* Bacteria

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Water body	**TMDL Development Priority**
Ashley Creek	High

Location: Dent County[1]

8-digit Hydrologic Unit Code (HUC):[2]
11010008 – Current River

12-digit HUC Subwatersheds[2]
110100080103 – Ashley Creek


Location of watershed in Missouri

Water Body Identifications (WBIDs) and Hydrologic Class:[3]
2668 - Class P

Designated Uses:[4]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Whole body contact recreation category B
Secondary contact recreation

Impaired Use:
Whole body contact recreation category B

Pollutant Identified on the 2022 303(d) List:
Escherichia coli (E. coli) (fecal indicator bacteria)

Identified Sources on the 2022 303(d) List:
Nonpoint source

Length and Location of Impaired Segments:
Ashley Creek (WBID 2668): 2.5 miles, from Mouth to Section 35, Township 32N, Range 7W

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[1] The impaired segment of Ashley Creek is completely within Dent County, however most of the watershed is in Texas County.

[2] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[3] For hydrologic classes see 10 CSR 20-7.031(1)(E). Class P streams maintain permanent flow even in drought periods.

[4] For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing a total maximum daily load (TMDL) to address elevated concentrations of *Escherichia coli* (*E. coli*) bacteria in Ashley Creek in Dent County. This TMDL report addresses one water quality limited segment that is on Missouri's 2022 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria concentration criterion.[5] This listing was approved by the U.S. Environmental Protection Agency (EPA) on August 8, 2023.[6]

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 7.031 consists of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacities for each water body are derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and are translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute to the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. In accordance with federal Clean Water Act Section 303(d)(1)(C) and 40 CFR 130.7(c)(l) a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies. The TMDL for any given pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

[5] A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2(j)).

[6] The department maintains current and past 303(d) lists and corresponding assessment worksheets online at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters.

North Ashley Creek (2670) at County Road 6633. 40 ft^3/s flow estimate. MoDNR file photo. January 2024

2. Watershed Description

Ashley Creek is located in south-central Missouri within the Current River subbasin, which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 11010008. Within this subbasin, the area of Ashley Creek 12-digit HUC watershed (110100080103) is 54 square miles. Ashley Creek water body identification number 2668 (WBID 2668) has two main tributaries, North Ashley Creek (WBID 2670) and South Ashley Creek (WBID 2671), both originating in northeastern Texas County. North Ashley Creek flows east for 8 miles and South Ashley Creek flows northeast for 6.7 miles to their confluence at Ashley Creek. From that confluence, Ashley Creek flows east 2.5 miles to the Current River (WBID 2662) (Figure 1). The Current River is listed as one of three Outstanding National Resource Waters within Missouri in Table D of 10 CSR 20-7.031. New releases are then prohibited within the Current River watershed that includes the Ashley Creek watershed per 10 CSR 20-7.031(8). The majority of the Ashley Creek watershed is located in Texas County with only the northeast corner of the watershed extending into Dent County. The entire impaired reach is located within Dent County and the watershed extends into Montauk State Park and the Ozark National Scenic Riverways. The only municipality within the watershed is Raymondville to the southwest.

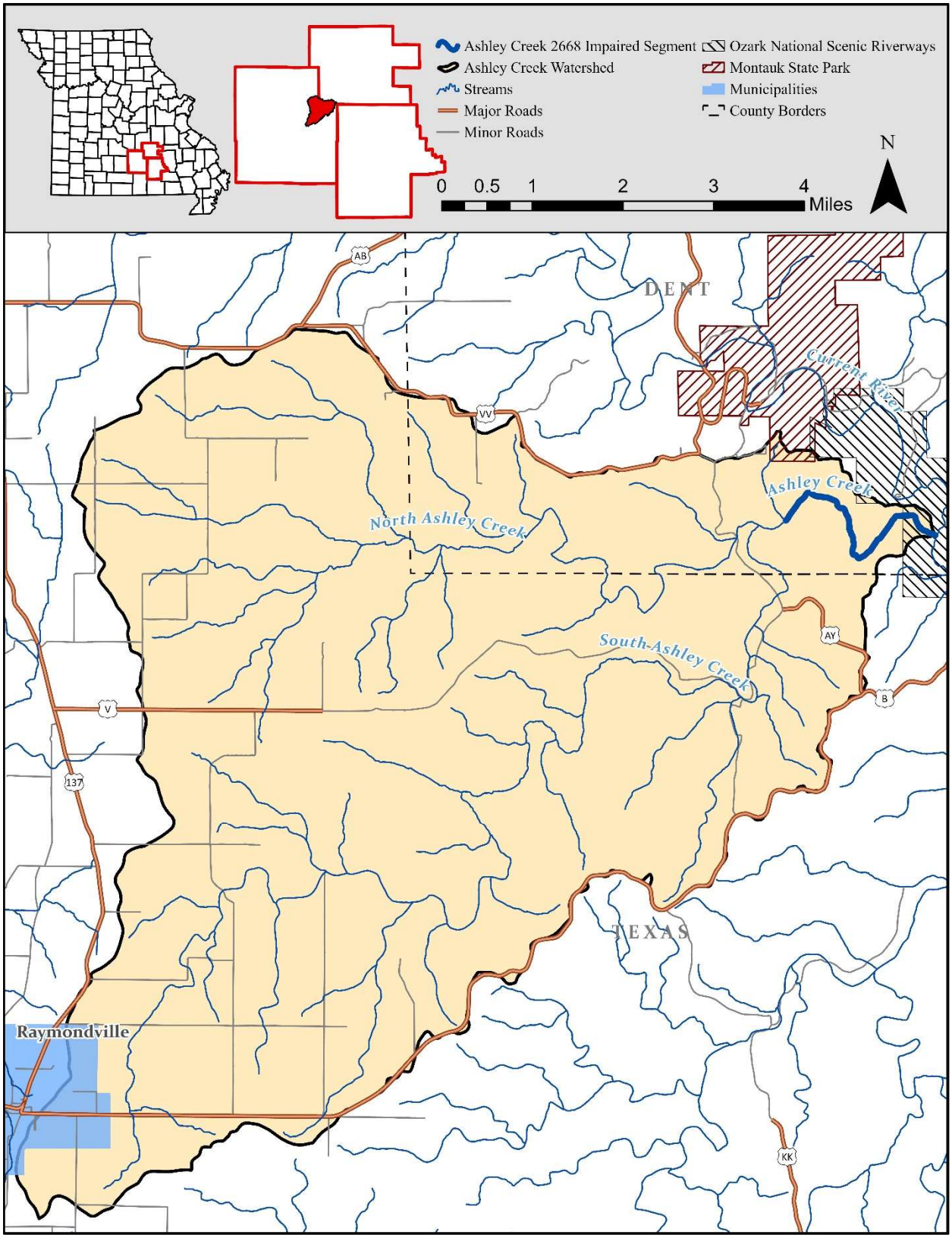

Figure 1. Ashley Creek Watershed

2.1 Geology, Physiography, and Soils

Ecological drainage units (EDU) are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). Ashley Creek is located within the Black/Current EDU, which straddles Missouri and Arkansas. The Black/Current EDU covers those portions of the Black, Current, and Eleven Point watersheds that fall within the Ozark Highlands. It is the most physiographically, hydrologically, and biologically diverse EDU in the state (MoRAP 2005). The Ozark aquatic subregion, which encompasses the Black/Current EDU, is one of three subregions in Missouri that differ in geology, topology, and soils. Aquatic subregions influence the distribution of aquatic life in the state. In general, streams in the Ozark aquatic subregion are heavily influenced by karst topography exemplified by increases in surface flows from springs or reductions due to losing streams. There are losing stream segments, two known springs, and 37 known sinkholes in the Ashley Creek watershed. Compared to the rest of the state, streams in this subregion typically have lower nutrient loads, cooler temperatures, and higher concentrations of dissolved oxygen (MoRAP 2005).

Within the Black/Current EDU, the Ashley Creek watershed drains from the Central Plateau into the Current River Hills EPA Level IV ecoregion (ecological subsection). Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H). The physiography of the Current River Hills EPA Level IV ecoregion is a deeply dissected landscape with steep slopes, narrow ridges, and narrow valley bottoms. Streams are very clear with relatively high gradients, gravel and cobble substrates, and abundant gravel bars within the active streambed. Soils consist of cherty soils and silt loams with moderate to slow infiltration rates. The high, gently rolling, dissected plains and hills are underlain mainly by resistant sandstones and dolomites. Weathering of the highly soluble dolomites has produced the karst landscape that dominates this subsection, including numerous large springs, losing streams, sinkholes, and caves (MoRAP 2005). Geographic Information System (GIS) analysis of the Ashley Creek watershed shows that 31 out of the 37 sinkholes are located near the headwaters of North and South Ashley Creek where the area is classified as the Central Plateau ecoregion.

The Central Plateau consists of some of the least dissected portions of the Ozark Highlands. It is dominated by a thick carbonate geology consisting mainly of cherty dolomites and some prominent sandstone components. Soils consist of cherty or silty loam with moderate to slow infiltration rates. This area is minimally dissected and many of the streams are either ephemeral or intermittent. Stream gradients are relatively low with smaller substrates of silt, sand, and gravel (MoRAP 2005).

Soils are categorized into hydrological soil groups based on similar runoff potentials. Each hydrological soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high-water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the

soil.[7] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Table 1 provides a summary of the hydrologic soil groups by area in square miles and relative percent. Figure 2 shows the distribution of hydrologic soil groups and karst features in the Ashley Creek watershed.

Table 1. Hydrologic Soil Groups in the Ashley Creek Watershed

Hydrologic Soil Group	Area in the Watershed	
	Square miles	Percent
Group A	5.32	9.85%
Group B	29.18	54.03%
Dual Group B/D	0.17	0.31%
Group C	4.41	8.16%
Dual Group C/D	8.32	15.41%
Group D	6.61	12.24%
Total	54.01	100.00%

[7] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

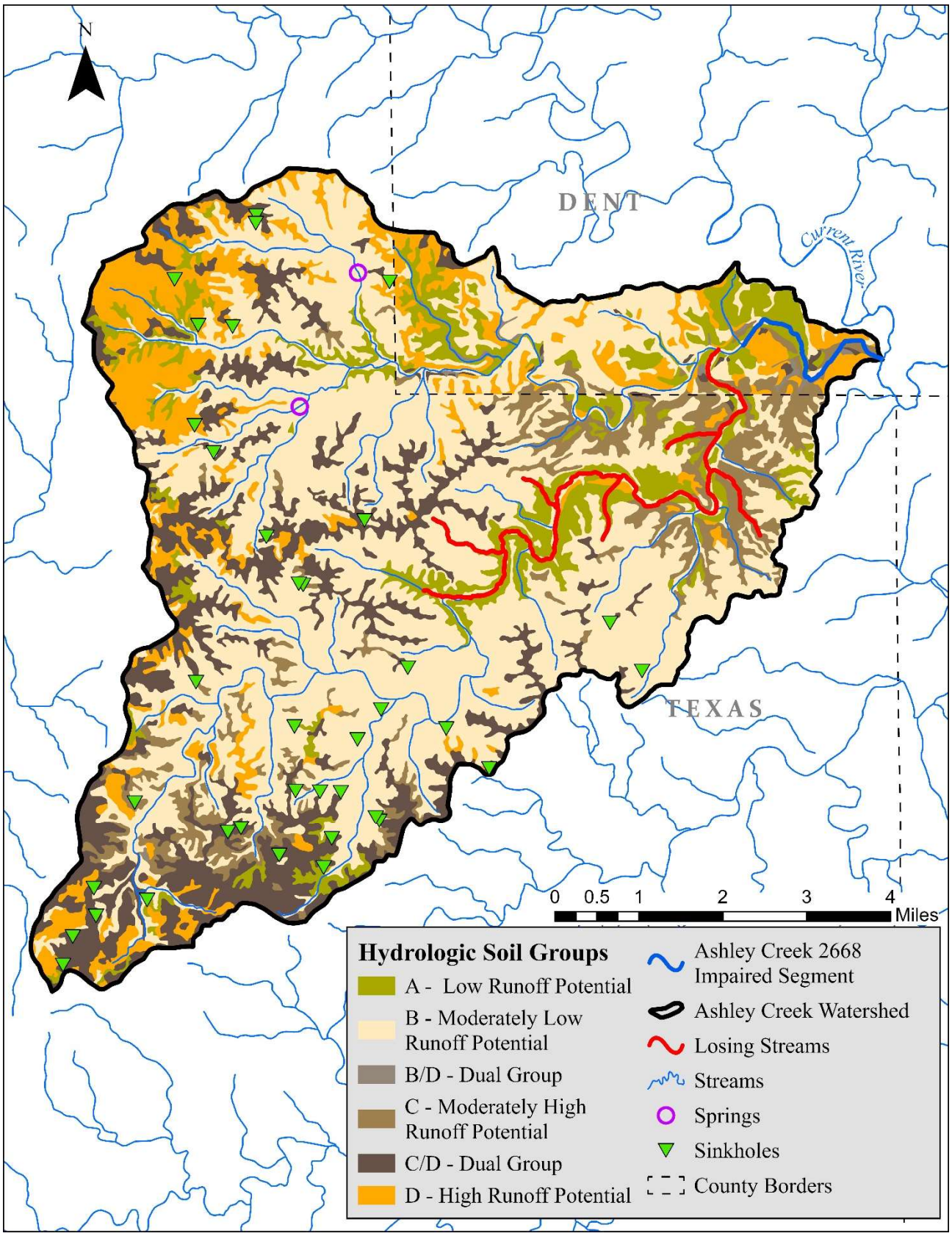

Figure 2. Hydrologic Soil Groups and Karst Features in the Ashely Creek Watershed

2.2 Climate

The most recent climate data from a weather station near the Ashley Creek watershed was measured at the National Centers for Environmental Information Waynesville Weather Station (USC00238777) in Pulaski County. The climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA 2020). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. Table 2 presents the 30-year monthly climate normals from the Waynesville Weather Station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 2. 30-year Monthly Climate Normals at the Waynesville Weather Station

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	in	ºF	ºF
January	2.69	22.4	44.1
February	2.72	25.6	49.2
March	4.08	34.3	58.9
April	4.81	44.3	69.3
May	5.18	53.9	76.8
June	4.67	63.0	84.5
July	4.30	66.9	89.1
August	4.61	65.1	88.6
September	4.18	56.4	81.3
October	3.56	44.6	71.1
November	3.76	34.7	58.3
December	2.90	26.6	47.7
	Total	**Average**	**Average**
	47.46	44.82	68.24

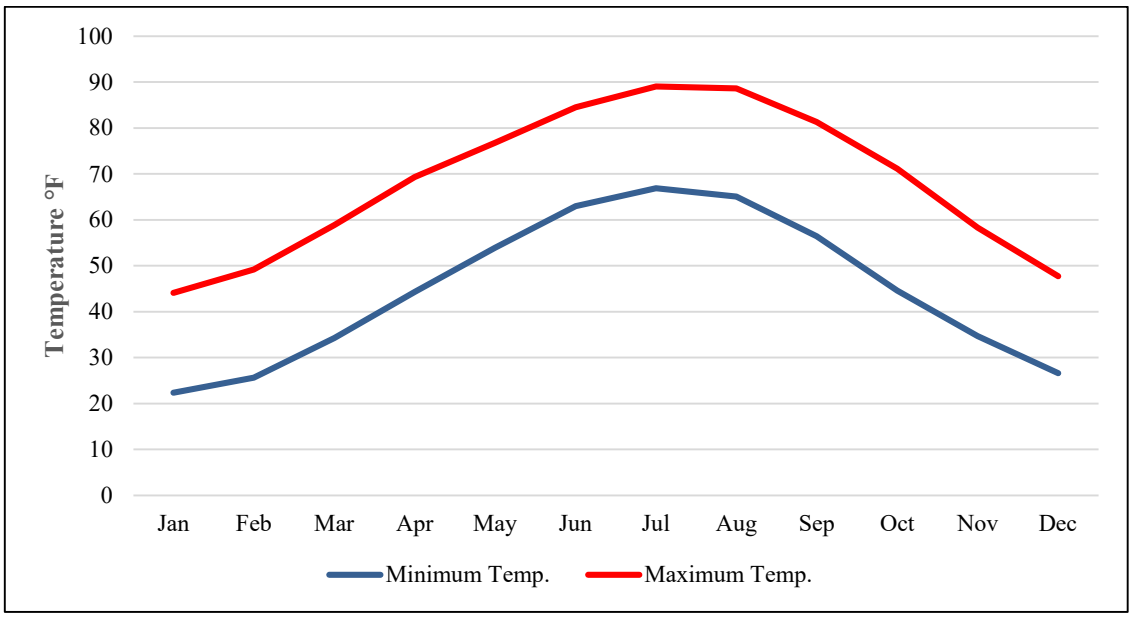

Figure 3. Monthly Minimum and Maximum Temperature Normals – Waynesville, MO

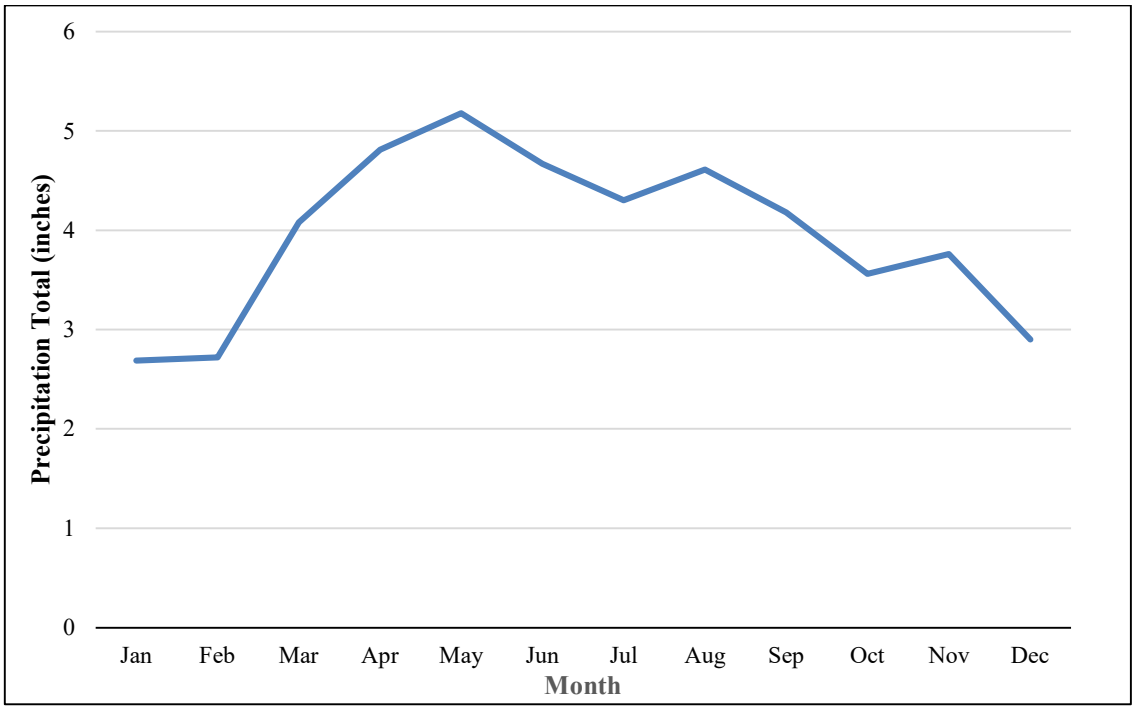

Figure 4. Monthly Precipitation Normals – Waynesville, MO

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2010 and 2020 census and can be localized using census block data (U.S. Census Bureau 2010; U.S. Census Bureau 2020). Population estimates for the Ashley Creek watershed were derived using GIS software by overlaying the watershed boundaries over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within a watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas were overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population. In 2020, the population was 93 percent rural and 7 percent living in municipal areas.

As shown in Table 3, the population in the Ashley Creek watershed has decreased since 2000. At the time of the 2020 census, the U.S. Census Bureau did not officially designate any urban areas in the watershed. Urban area designation is one criterion used to determine whether a municipality is subject to municipal separate storm sewer system (MS4) regulations. The lone municipality partially within the Ashley Creek watershed, Raymondville, is not subject to MS4 regulations.

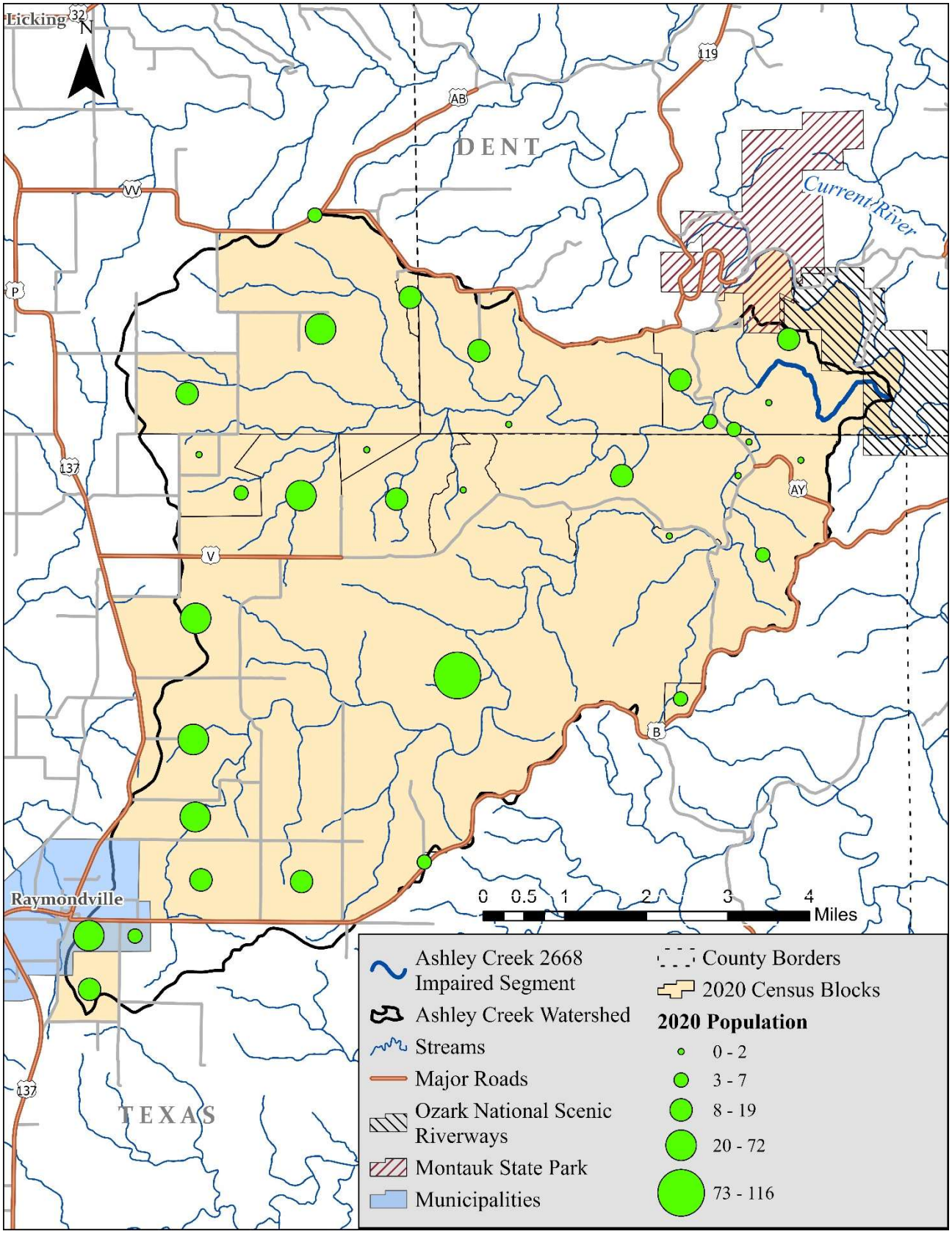

Figure 5. 2020 Population in the Ashley Creek Watershed

Table 3. Population Estimates for the Ashley Creek Watershed

Municipal			Rural			Total		
2000	**2010**	**2020**	**2000**	**2010**	**2020**	**2000**	**2010**	**2020**
41	28	39	637	586	558	678	614	597

U.S. Census Bureau data can also assist with identifying areas in the watershed with potential environmental justice concerns. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities having environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. One example of financial assistance the department offers that may be available to communities having environmental justice concerns is Section 319 grant funding to address nonpoint sources. The department evaluates 319 grants on a number of criteria but gives higher priority for selection to proposed projects in disadvantaged communities. Additional grant and financial resource information is available on EPA's environmental justice website at www.epa.gov/environmentaljustice. Demographic index is one approach that may be used to identify areas where there may be potential environmental justice concerns. The index is computed by the following equation:

$$Demographic\ index = \frac{\%\ People\ of\ Color + \%\ Low\ Income}{2}$$

The demographic data used in this analysis is from the U.S. Census Bureau and the index is derived from the Demographic Index used in EPA's web based Environmental Justice Screening and Mapping (EJSCREEN) tool. The EJSCREEN tool is available at https://www.epa.gov/ejscreen. This index is displayed as the state's percentile to compare areas more easily across the state. The EJSCREEN is divided up into census block groups but not smaller census blocks. There are four census block groups that intersect the Ashley Creek watershed. They each have demographic indexes of either 49th, 64th or 76th percentile (Figure 6). The 76th percentile block group represents the southern portion of the Ashley Creek watershed as well as areas southeast of Raymondville outside the watershed. Meaning that its demographic index is 76 percent higher than other census block groups within the state of Missouri.

Environmental justice encompasses a wide set of concerns and demographics. In addition to the Demographic Index, the EJSCREEN tool integrates 11 environmental pollution and 6 demographic indicators. Due to the numerous factors considered by the EJSCREEN tool, the department provides only generalized information in this TMDL. Local communities can identify and prioritize other environmental justice concerns for their watershed.

Another available tool for identifying potentially disadvantaged communities is the Climate and Economic Justice Screening Tool (https://screeningtool.geoplatform.gov/). This tool is maintained by the Council on Environmental Quality and incorporates various environmental, health, economic, and census demographic datasets to identify communities that may be overburdened or underserved. This tool identifies areas of Texas County and Raymondville in the Ashley Creek watershed as potentially being disadvantaged due to population loss and low income.

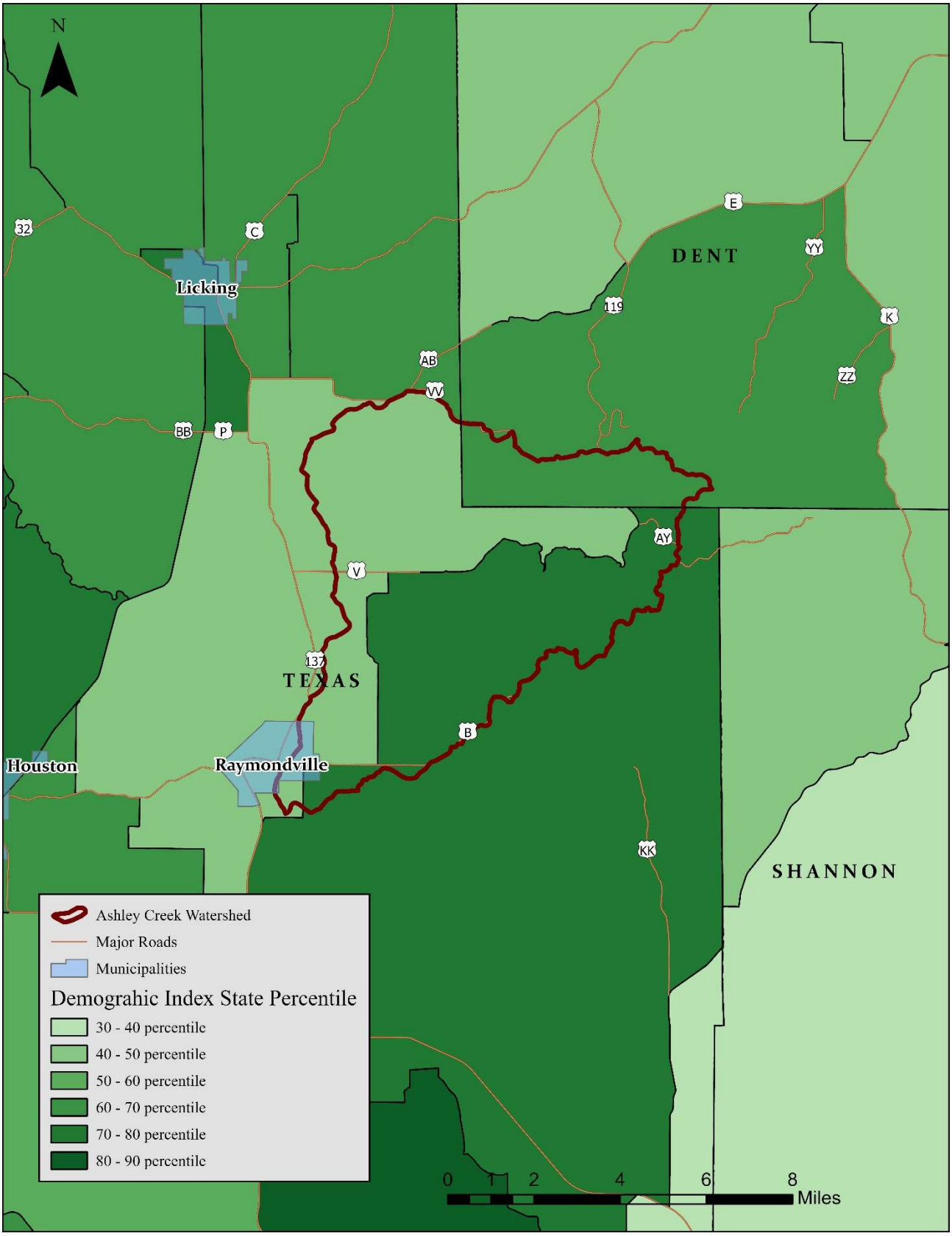

Figure 6. Demographic Index

2.4 Land Cover

A land cover analysis was completed using the 2019 National Land Cover Database published by USGS (Dewitz 2021). Land cover types present in the Ashley Creek watershed are summarized in Table 4. Figure 7 depicts the distribution of the land cover types throughout the watershed. Hay and pasture areas potentially used for livestock grazing cover approximately 21 percent of the watershed, while forest covers the majority at 73 percent. Developed areas, where impervious surfaces are more common, account for less than 3 percent of the total watershed area.

Table 4. Land Cover in the Ashley Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.0003	0.001%
Developed, Medium Intensity	0.0230	0.043%
Developed, Low Intensity	0.1374	0.254%
Developed, Open Space	1.2882	2.385%
Barren Land	0.0012	0.002%
Hay and Pasture	11.6711	21.609%
Shrub and Herbaceous	1.3010	2.409%
Forest	39.5503	73.227%
Wetlands	0.0137	0.025%
Open Water	0.0244	0.045%
Total	54.0106	100.000%

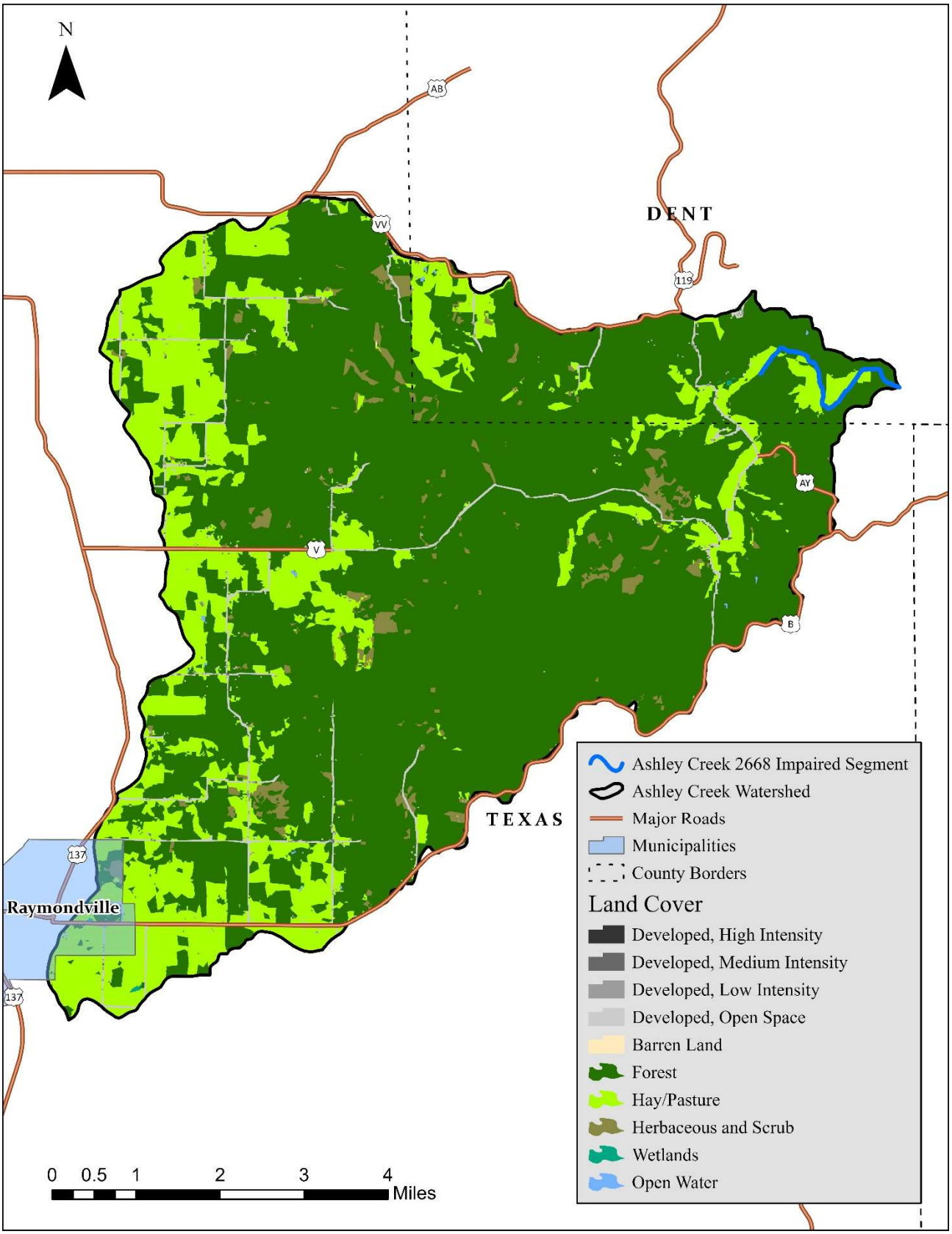

Figure 7. Land Cover in Ashley Creek Watershed

3. Applicable Water Quality Standards

Total maximum daily loads identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10(b), Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.[8]

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(F) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes), and Table H (Streams). Missouri's Water Quality Standards designate the following uses of Ashley Creek:

- Irrigation
- Livestock and wildlife protection
- Human health protection
- Warm water habitat (aquatic life)
- Whole body contact recreation category B
- Secondary contact recreation

The whole-body contact recreation category B designated use of Ashley Creek is impaired due to high *E. coli* bacteria concentrations. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CSR 20-7.031(1)(F)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(F)2.A.(I)). Whole body contact category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(F)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(F)2.B.).

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general

[8] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. Ashley Creek has a designated use of whole-body contact recreation category B and the *E. coli* bacteria criteria is that concentrations during the recreational season (April 1 through October 31) shall not exceed the geometric mean of 206 colony forming units (cfu) per 100 milliliters (mL) of water. This criterion is also protective of secondary contact recreational uses.

For this TMDL, however, criteria for the protection of the whole-body contact recreation category A use is targeted for Ashley Creek. This is to provide additional assurance for the attainment and maintenance of downstream water quality in the Current River. The *E. coli* bacteria criterion for whole body contact recreation category A is applicable during the recreational season (April 1 through October 31) and shall not exceed the geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL) of water.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulations related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Ashley Creek are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In accordance with Missouri's 2022 Listing Methodology Document, the whole body contact recreation category B designated uses for Ashley Creek are impaired because the geometric means of *E. coli* samples collected during the recreational season (April 1 through October 31) were greater than 206 cfu/100 mL in the most recent three years having available data with five or more samples.[9] Sufficient data consistent with the assessment methodology are available to support these listings as summarized in Table 5 and Figure 8. All samples were taken at 0.1 mile upstream of the mouth of Ashley Creek before it empties into the Current River. As shown, *E. coli* concentrations exceeded the geometric mean of 206 cfu/100 mL during the recreational season in Ashley Creek in 2012, 2021, 2022, and 2023.

Figure 8 shows the geometric mean of *E. coli* by month within the recreation season, however, there are a limited number of samples taken at Ashley Creek. The months of April and May each only have one sample and therefore a geometric mean cannot be calculated. Those months are not included in Figure 8 and this does not invalidate the impairment listing.

Individual *E. coli* measurements are provided in Appendix A to illustrate the nature of the impairment but were not used in the calculation of TMDL loading capacities or allocations. Individual measurements may be used to estimate existing loading and pollutant reduction targets to target implementation activities, and to select appropriate best management practices (BMPs). Reduction targets for Ashley Creek are presented in a supplemental Voluntary Nonpoint Source Implementation Strategies document available online at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Table 5. Summary of Recreational Season *E. coli* Data for the Impaired Water Body

Water Body	Recreational Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean[10] (cfu/100 mL)
Ashley Creek WBID 2668	2010	3	18.1	133.6	56.7
	2011	9	25.6	325.5	95.7
	2012	9	48.0	2,419.6	417.0
	2017	1	121.1	121.1	Insufficient data
	2021	5	93.3	648.8	246.7
	2022	5	111.9	2,419.6	406.0
	2023	5	144.9	547.5	300.7

[9] Listing Methodology documents are available online at https://dnr.mo.gov/document-search/methodology-development-2022-section-303d-list-missouri

[10] Although geometric means are presented for all years of available data, only years with a minimum of five samples were used for assessment purposes.

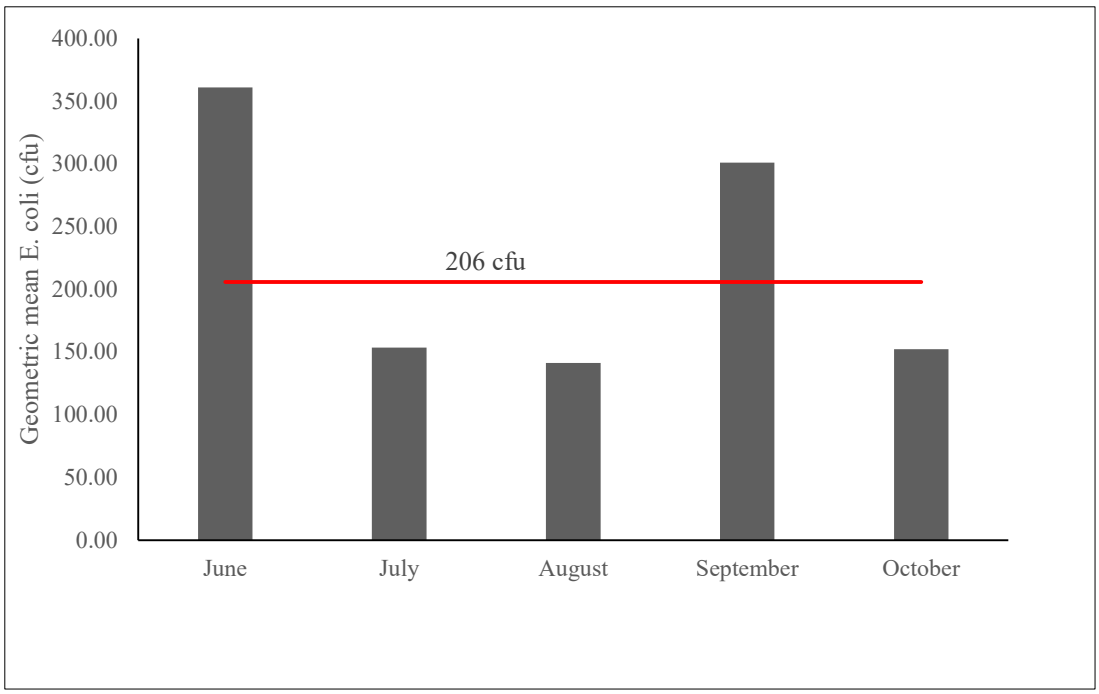

Figure 8. Geometric means for *E. coli* by month from 2010-2012, 2017, and 2021-2023[11]

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to elevated *E. coli* concentrations in an impaired water body. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading to Ashley Creek. Sources of bacteria loading are identified and quantified to the extent that information is available.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[12] A point source is defined as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural storm water discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial facilities, concentrated animal feeding operations (CAFOs), MS4s, and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. The locations of permitted point sources in the Ashley Creek watershed are presented in Figure 9. Facility types and their expected contributions to the impaired stream are described individually in the following sections.

[11] Only includes months with more than one sample to calculate a geometric mean.

[12] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain an NPDES permit. Issued and proposed operating permits are available online at dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees

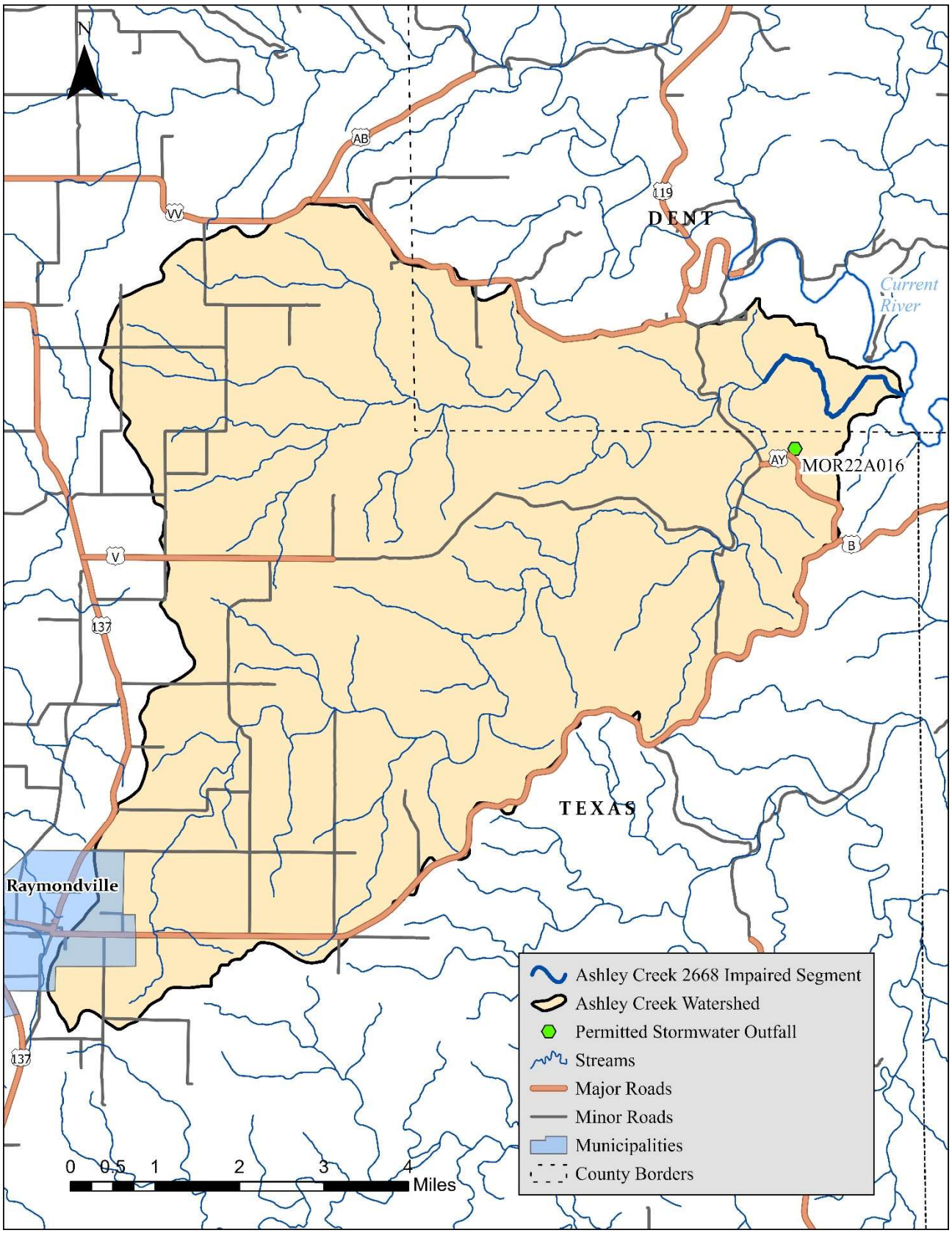

Figure 9. Permitted Facilities in the Ashley Creek Watershed

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). Facilities equipped with disinfection technologies discharge *E. coli* at very low concentrations and are not expected to cause or contribute to bacteria impairments through discharges of treated effluent. Within the Ashley Creek watershed there are no domestic wastewater treatment facilities. The city of Raymondville does operate a wastewater treatment plant however, it discharges to a creek outside the Ashley Creek watershed.

Potential bacteria loading from domestic wastewater treatment facilities may also occur from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases industrial wastewater, to the domestic wastewater treatment facility. Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater but are typically not designed to collect large amounts of runoff from precipitation events. Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows can be caused by high volume precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

The Raymondville Wastewater Treatment Facility reported one sanitary sewer overflow in 2014. This overflow occurred at a residence outside of the Ashley Creek watershed and lime was placed on the affected area. It is not expected that this spill contributed any bacteria loading to Ashley Creek. Sanitary sewer overflows are not expected to be a significant contributor of *E. coli* to Ashley Creek because unintentional discharge of untreated domestic wastewater is rare and temporary in nature. National Pollutant Discharge Elimination System (NPDES) permits, and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their collection systems. This is implemented through a special permit condition or schedule of compliance.

5.1.2 Industrial Facilities

Industrial facilities discharge process water used or generated during mining, manufacturing, or food processing activities, and may also include landfills. There are no industrial facilities discharging process wastewater in the Ashley Creek watershed.

5.1.3 Concentrated Animal Feeding Operations

Animal waste generated from CAFOs can be a source of bacteria to water bodies (Rogers & Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.[13] Permits

[13] As defined by 10 CSR 20-6.300(1)(B)2, an animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poults in brood phase without a wet handling system.

may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. There are no permitted CAFOs present in the Ashley Creek watershed.

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more. As of 1999, new federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority. As discussed in Section 2.3, at the time of the 2020 census, the U.S. Census Bureau did not designate any areas in the watershed as urban areas. There are no regulated MS4s in the Ashley Creek watershed. Unregulated runoff from developed areas is discussed in Section 5.2.2.

5.1.5 Stormwater Facilities

General permits are issued for certain stormwater (MO-R) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance but must also protect water quality. General stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 6 lists the effective stormwater discharge permit in the Ashley Creek watershed as of June 2024. Permits associated with construction or land disturbance activities (MO-RA) are temporary. Although there are currently no land disturbance permits in the Ashley Creek watershed, the number of permits of this type may vary in any given year. Despite this variation, activities associated with general construction or land disturbance permits are not expected to cause or contribute to *E. coli* impairments when all permit conditions are met.

Existing and future activities for which general stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. Activities conducted in accordance with general stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the department determines that a general permit is not providing adequate water quality protection, the department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit.

Table 6. General Stormwater Permit in the Ashley Creek Watershed

Watershed	Permit No.	Facility Name	Permit Type	Expires
Ashley Creek	MO-R22A016	Spencer Brothers Lumber Co INC	Stormwater from Lumber and/or Wood Operations	9/16/2024

5.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown et al. 2004). Illicit straight pipe

discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Ashley Creek watershed. For this reason, it is unknown to what significance, if any, straight pipe discharges contribute bacteria loads to surface waters in the watershed. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and they include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions.

Although there are no specific *E. coli* data to indicate contributions from specific nonpoint sources, common nonpoint sources that have the potential to contribute bacteria loading to surface waters include agricultural lands, onsite wastewater treatment (septic) systems, and developed areas that do not have regulated storm sewer systems. Agricultural lands associated with land application of wastewater or sludge from permitted facilities, including CAFOs, are also considered nonpoint sources, so long as the activities meet agricultural practices and agronomic land application rates, without direct discharge from land application activities.[14]

Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution. The department provides guidance and examples of BMPs to help reduce pollutant loading from nonpoint sources in the supplemental Voluntary Nonpoint Source Implementation Strategies document for Ashley Creek at: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. These actions are voluntary and not a requirement of this TMDL. However, efforts to reduce pollutant loading from any potential nonpoint source contributor in the watershed is encouraged and will aid in meeting the water quality goals of this TMDL.

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential nonpoint sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure, including poultry litter, and where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide manure application and where BPMs are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are

[14] Per Missouri Clean Water Law at 644.059 and 644.016(16) RSMo, and Missouri permit regulations at 10 CSR 20-6.300(1)(B)10, discharges of agricultural stormwater are separate from CAFO discharges and are considered nonpoint sources.

not excluded from streams can defecate while wading and thus deposit bacteria directly into the waterway.

As noted in Section 2.4 of this document, the Ashley Creek watershed is dominated by forest cover, but hay and pasture still account for 21 percent of the watershed. The exact type and number of livestock present in the Ashley Creek watershed is unknown. Since there are no cattle CAFOs in the watershed, the number of cattle in the watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2022 Census of Agriculture (NASS 2022). Based on the 2022 agricultural census, there are an average of 257 cattle per square mile of hay/pasture in Texas County and 202 cattle per square mile of hay/pasture in Dent County. There are approximately 10.24 square miles of hay/pasture from the Ashley Creek watershed within Texas County and 1.43 square miles of hay/pasture from Dent County that drain into Ashley Creek. This indicates that there are approximately 2,917 cattle in the Ashley Creek watershed[15]. The U.S. Department of Agriculture estimates that a 1,000-pound beef cow produces approximately 59.1 pounds (26.8 kilograms) of manure per day (USDA 1995). Another study found that 1 gram of fresh manure from a cow on pasture contains a population of approximately 758,577 *E. coli* (Weaver et al. 2005). A single *E. coli* cell can grow into a colony containing 10^8 cells every 12 hours (Lodish et al. 2000). This means that each 1,000-pound cow has the potential to produce 422 cfu per day.

Horses are another potential contributor of bacteria from agricultural lands. The U.S. Department of Agriculture's 2022 Census of Agriculture (NASS 2022) reports 1,194 horses and ponies across Texas County as a whole and 689 horses and ponies across Dent County. These numbers are substantially lower than the cattle but could still be contributing bacteria to the Ashley Creek watershed.

Other types of livestock such as swine, donkeys, goats, and sheep may also be contributing bacteria loads in the Ashley Creek watershed. The number and distribution of other animals in the watershed cannot be estimated from available data. Strategies to reduce *E. coli* loading from agricultural areas are outlined in the Voluntary Nonpoint Source Implementation Strategies document for Ashley Creek located at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

5.2.2 Runoff from Developed Areas

As discussed in Section 5.1.4, there are no regulated MS4s in the Ashley Creek watershed. Developed areas where stormwater discharges are not regulated through MS4 permits are potential nonpoint sources of *E. coli* loading. Stormwater runoff from municipal areas may carry high levels of bacteria exceeding water quality criteria during and immediately after storm events (USEPA 1983). *E. coli* contaminated runoff can come from heavily paved areas and areas where soil erosion is common. Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton & Pitt 2002). Irrigation runoff from residential lawns where pet wastes are present may also contribute *E. coli* loads to surface waters.

[15] This analysis assumes all areas identified as hay and pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

As presented in Section 2.4, developed areas cover small portions of the total Ashley Creek watershed. Areas categorized as low to high intensity development comprise approximately 0.3 percent of the watershed and areas described as developed open space comprise approximately 2.38 percent of the watershed. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold & Gibbons 1996; Schueler 1994). Due to the small amount of developed area in the watershed, runoff from these areas is not expected to contribute substantial amounts of *E. coli* to the impaired water body. If the developed areas are expanded in the future, BPMs and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment (septic) systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley & Witten 1996). The Missouri Department of Health and Senior Services (DHSS) or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of septic systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri utilize onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows. Factors that may contribute to onsite wastewater treatment system failure include age, inadequate land area, poor soil for drainage, high water table, and inadequate maintenance. Proper maintenance of onsite residential wastewater treatment systems including septic tanks, associated drain fields, and household lagoons should minimize bacteria loading to surface waters.

The exact number of onsite wastewater treatment systems in the Ashley Creek watershed is unknown. EPA's online input data server for the Pollutant Load Estimation Tool (PLET) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[16] According to the data provided by this server, there are approximately 63 septic systems in the Ashley Creek watershed. Although there has been a slight increase in population since the 1990 census, this data is assumed to provide a reasonable estimate of actual septic system numbers.

Septic systems fail due to age and poor maintenance. A study by the Electric Power Research Institute suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing (EPRI 2000). Due to this high failure rate, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, at the time of this writing, the significance of such contributions to the *E. coli* impairments in the Ashley Creek

[16] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

watershed is unknown. The greater the distance an onsite system is located from a surface water, the less likely it is to cause contamination (MU Extension 2023).

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, feral hogs, rodents, black bears, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions are a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for Canada geese or other waterfowl, but the Missouri Department of Conservation (MDC) conducts statewide surveys in fall and winter. In 2020, waterfowl counts ranged from approximately 59,000 in October to 760,000 in late November (MDC 2021).

The exact number of deer in the watershed is also not known, but MDC keeps harvest records by county for each hunting season. Harvest data provides a general idea of the number of deer that may be present in an area. The total harvests for 2022 in Texas County was approximately 4,700 deer and 3,351 deer in Dent County (MDC 2022).

MDC does not survey or track the number of feral hogs in the state but does report total hogs removed, acres scouted, and landowner contacts. This number is becoming a more accurate representation of feral hogs in the state since their hunting was banned on MDC properties, Mark Twain National Forest, and Ozark National Scenic Riverways. In 2021, MDC removed 126 hogs from Texas County and 152 from Dent County. Feral hogs have been shown to increase *E. coli* bacteria levels in creeks, streams, and rivers (Jay et al. 2007). The significance of contributions from wildlife is unknown but remain potential sources of loading. Background concentrations of bacteria may also be present in benthic sediments and, if disturbed, can be resuspended as bacteria lives longer in sediment than in water (Davis & Barr 2006; Marino & Gannon 1991). The significance of any resuspended bacteria to the impairment in the Ashley Creek watershed is also unknown. Natural background contributions are included in the total nonpoint source load allocation.

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Ashley Creek watershed are presented in Table 7. Agricultural areas constitute over 13 percent of the riparian corridors of streams in the Ashley Creek watershed. These areas may be more susceptible to *E. coli* loading. Over 83 percent of the riparian corridors in the Ashley Creek watershed are forested. This indicates that some *E. coli* transported from adjacent pasture lands into those areas may be intercepted before it enters the streams.

Table 7. Land Cover in Riparian Corridors in the Ashley Creek Watershed

Land Cover Type	Total Watershed	
	Square Miles	Percent
Developed, Low Intensity	0.004	0.08%
Developed, Medium Intensity	0.001	0.03%
Developed, Open Space	0.057	1.26%
Forest	3.773	83.61%
Hay/Pasture	0.624	13.82%
Open Water	0.003	0.06%
Shrub and Herbaceous	0.045	1.00%
Wetlands	0.006	0.14%
Total	4.513	100.00%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. These allocations become the pollutant loading targets to restore water quality. A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDL for Ashley Creek is expressed as *E. coli* cfu per day using a load duration curve developed using the *E. coli* criterion concentration target of 126 cfu/100 mL, all possible stream flows, and a unit conversion factor.[17] The whole body contact A use criterion, the most stringent downstream criteria, was targeted for Ashley Creek. This is to provide additional assurance of the attainment and maintenance of water quality in downstream waters as required by 40 CFR 131.10(b). The downstream water body with whole body contact A use criteria, therefore requiring the *E. coli* criterion concentration target of 126 cfu/100mL, is the Current River (WBID 2662). Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling

[17] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{time}}\right) = \boldsymbol{Concentration}\left(\frac{\text{count}}{\text{volume}}\right) * \boldsymbol{Flow}\left(\frac{\text{volume}}{\text{time}}\right) * \boldsymbol{conversion\ factor}$ (24,465,715)

(*Friends of the Earth, Inc., et al v. EPA,* No. 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

The selected TMDL target is protective of applicable whole body and secondary contact recreational uses. The resulting load duration curve provides a visual representation of the pollutant loading capacity of the water body at all stream flows. The TMDL is applicable during the recreational season (April-October) when the *E. coli* criterion applies. Using this approach, the available loading capacity of the stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, *E. coli* criteria are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curve for Ashley Creek is provided in Appendix B.

Observed data are plotted on the load duration curve graph to illustrate the frequency of exceedance and the magnitude of load reductions needed to meet the TMDL. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curve also helps to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be calculated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Voluntary Nonpoint Source Implementation Strategies document located at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

The *E. coli* load duration curve for Ashley Creek is displayed in Figure 10. The y-axis quantifies the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axis. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The TMDL and associated allocations at selected percentile flow exceedances are displayed in Table 8. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Specific allocations for individual sources are discussed in Sections 8 and 9.

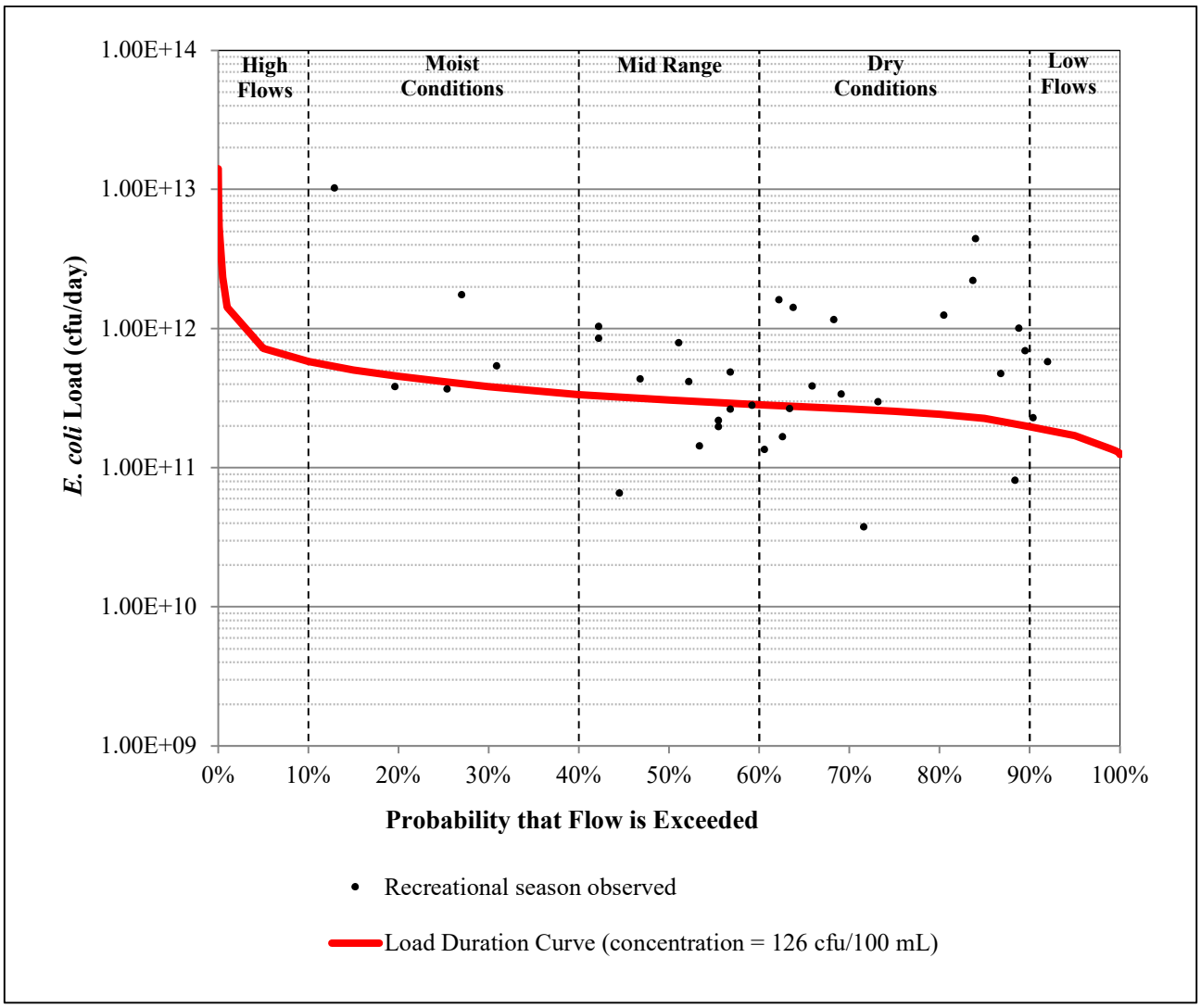

Figure 10. *E. coli* TMDL for Ashley Creek (WBID 2668)

Table 8. *E. coli* TMDL and Allocations for Ashley Creek at Selected Flows

Percent of time flow is equaled or exceeded[18]	Flow ft^3/s	LC* (cfu/100mL)	∑WLA (cfu/100mL)	∑LA* (cfu/100mL)	MOS* (cfu/100mL)
100-90	55.09	1.70E+11	0.00E+00	1.53E+11	1.70E+10
90-60	82.28	2.54E+11	0.00E+00	2.28E+11	2.54E+10
60-40	99.15	3.06E+11	0.00E+00	2.75E+11	3.06E+10
40-10	134.96	4.16E+11	0.00E+00	3.74E+11	4.16E+10
10-0	233.19	7.19E+11	0.00E+00	6.47E+11	7.19E+10

* Due to rounding and the limited number of decimal places displayed, summation of the allocation values displayed may not exactly match the presented load capacity in all cases.

[18] The percent of time flow is equaled or exceeded is a statistical measure used to divide the load duration curve into flow ranges that are indicative of low flow, dry conditions, mid range, moist conditions, and high flows. For example, a 10% value indicates a high flow that only occurs 10% of the time.

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. No portion of the *E. coli* loading capacities for Ashley Creek were allocated to point sources because the existing point sources either do not discharge wastewater that contains *E. coli* or operate under permits that do not allow discharge to surface waters. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a) disallows the issuance of an NPDES permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* will be required to disinfect its effluent during the recreational season or use other approaches (e.g., no discharge or batch discharges) that will result in negligible bacteria loading during the recreational season and will therefore not cause or contribute to the impairment, or be allowed to exceed the sum of the wasteload allocation. Decommissioning of onsite wastewater treatment systems and connecting to a sewer system for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL.

8.1 Domestic Wastewater Treatment Facilities

The Raymondville Wastewater Treatment Facility is located outside the Ashely Creek watershed and there are no other domestic wastewater treatment facilities within the watershed. Therefore, domestic wastewater treatment facilities are not expected to contribute *E. coli* loads to Ashley Creek. Additionally, effluent regulations at 10 CSR 20-7.015(6)(A)2.A prohibit new releases from domestic wastewater treatment facilities to Outstanding National Resource Waters. For these reasons, the *E. coli* wasteload allocation for all domestic wastewater facilities is zero at all flows.

8.2 Industrial Facilities

There are no site-specific permits for industrial dischargers in the Ashley Creek watershed. Effluent regulations at 10 CSR 20-7.015(6)(A)3 prohibit discharges from industrial sources to Outstanding National Resource Waters. For this reason, the *E. coli* wasteload allocation for industrial facilities is zero at all flows.

8.3 Concentrated Animal Feeding Operations

There are no permitted CAFOs in the Ashley Creek watershed. Concentrated Animal Feeding Operations permits also do not allow discharge to surface waters. For these reasons, the *E. coli* wasteload allocation for CAFOs is zero at all flows.

8.4 Municipal Separate Storm Sewer Systems

There are no regulated MS4s in the Ashely Creek watershed. *E. coli* in stormwater runoff from developed areas are included in the load allocation for nonpoint sources. If MS4 permits are required for stormwater discharges from urban areas in the future, then the appropriate proportion of

the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation.

8.5 Stormwater Facilities

The one permitted facility within the Ashley Creek watershed is Spencer Brothers Lumber Co INC, MO-R22A016 that has a general stormwater industrial permit. Activities that require general or stormwater permits are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watershed. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any BMPs, land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For these reasons, the *E. coli* wasteload allocation for this facility is set at zero at all flows. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above negligible levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act or Missouri Clean Water Law. For this reason, illicit straight pipe discharges are assigned *E. coli* wasteload allocations of zero. Any existing illicit straight pipe discharges must be eliminated, and future discharges of this type should be prevented.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). Because the wasteload allocations for all point sources are zero, the *E. coli* load allocations are equal to the loading capacity minus the explicit margin of safety as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocations is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed, they do not discharge *E. coli* directly to surface waters.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Uncertainty can also be associated with data collection, analysis of samples, analysis of data, modeling errors, and observed daily flow. Utilizing a margin of safety assures that allocations will result in attainment of water quality standards. Based on EPA guidance (USEPA 2001), the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

For this TMDL, both implicit and explicit margins of safety are used. Bacteria decay rates were not applied, and the direct recreational-season geometric mean concentration was applied as a target for estimating daily loading values as required by the federal Clean Water Act. These conservative

assumptions serve as implicit margins of safety and are applicable during all flow conditions. Additionally, Ashley Creek is designated for whole body contact recreation category B, however, TMDL targets are based on the more stringent criterion applicable for category A. This approach provides added confidence that downstream waters, where the more stringent geomean criterion may apply, are protected, and, at the same time, requires additional pollutant reductions much greater than needed for attainment of the category B use. This TMDL also assigns all allowable loading to the nonpoint source load allocation during low flow and dry conditions. In reality, most nonpoint source contributions occur as a result of precipitation-based events and are less likely to occur or occur in less significant amounts during these dry weather periods. An explicit margin of safety equal to 10 percent of the loading capacity is applied at all flow conditions in addition to the previously mentioned implicit margins of safety.

It should be noted that Missouri's recreational bacteria criteria, and targets used in this TMDL, do not differentiate between human and nonhuman sources of *E. coli*. Technical support materials published by EPA in 2024 and a quantitative microbial risk assessment published by EPA in 2010 note decreased risk of illness associated with recreational uses in waters where *E. coli* contamination occurs from nonhuman sources, such as livestock, manure, or wildlife (USEPA 2024 and USEPA 2010). In some instances, risks of illness from recreational exposure were described as being 20 to 30 times less in animal-impacted waters than human-impacted waters (USEPA 2010). Although conservative assumptions incorporated into water quality criteria are not implicit margins of safety as it pertains to TMDLs, such information lends support that TMDL targets will be greatly protective of recreational uses in largely forested and agriculturally dominated Ashley Creek watershed, where human inputs are less likely or significantly less than animal sources.

Through the department's assessment methodologies and approach for development of this TMDL, effort was made to reduce overall uncertainty in the analyses. A majority of the *E. coli* samples collected over the last ten years were analyzed using an enzyme-specific media (Idexx/Colilert method). This method helps reduce variability, thus resulting in a more accurate and higher *E. coli* yield as compared to if conventional culture media are used. Additionally, when calculating the load duration curve and estimating stream flow duration, the department used verified measured flow data from a USGS gage station. Together, these quality assured data were used to provide estimates of existing loading from which pollutant reduction targets can be derived.

Due to reduced uncertainty in the analysis and calculation of loading targets, along with the various implicit margins of safety outlined above, the approach used to calculate this TMDL appropriately includes an adequate and sufficient margin of safety to fulfill the requirements of 40 CFR 130.7(c)(l). The use of an additional explicit margin of safety of 10 percent is intended to account for other unspecified and unquantified uncertainties or unknowns. Reserving a portion of the available loading capacity and not allocating it to either point or nonpoint sources only further ensures that water quality standards will be achieved when all wasteload and load allocations are achieved.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curve provides the *E. coli* loading capacities for Ashley Creek at all possible flow regimes using data collected during all seasons. The *E. coli* TMDL is therefore protective of designated recreational uses throughout the recreational

season, including during high flows associated with intense rainfall events when bacteria loading is more likely.

12. Monitoring Plans

The department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit compliance schedules, or the implementation of watershed BMPs. The department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved, and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the NPDES permitting program. State operating permits requiring effluent and instream monitoring be reported to the department provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or best management practices within the watershed. If BMPs or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or BMPs are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the Ashley Creek watershed are provided in the supplemental Voluntary Nonpoint Source Implementation Strategies document available online at: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

14. Public Participation

EPA regulations at 40 CFR 130.7(c)(ii) require that TMDLs be subject to public review. A 45-day public notice period for this TMDL report was scheduled from August 2, 2024, through September

16, 2024. Groups that directly received notice of the public comment period for this TMDL include, but are not limited to:

- Missouri Clean Water Commission
- Missouri Department of Conservation
- Meramec Regional Planning Commission
- South Central Ozark Council of Governments
- Texas and Dent County Soil and Water Conservation Districts
- County health departments
- County commissions
- University of Missouri Extension
- Missouri Coalition for the Environment
- Stream Teams United
- Missouri Farm Bureau
- Stream Team volunteers living in or near the watershed, and
- Missouri state legislators representing areas within the watershed

In addition to those groups directly contacted about the public notice, this TMDL report and a Voluntary Nonpoint Source Implementation Strategies document are posted on the department's TMDL webpage https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. All comments received during this period and the department's responses to those comments are also available at this location for 30 days after submittal or until EPA approval, whichever is longer.

The department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The department has an administrative record on file for the Ashley Creek *E. coli* TMDL. The record contains information on which the TMDL is based. It additionally includes the Voluntary Nonpoint Source Implementation Strategies document, the public notice announcement, any public comments received, and the department's responses to those comments. This information is available upon request to the department at dnr.mo.gov/sunshinerequests.htm. The department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMo) and the department's administrative policies and procedures governing Sunshine Law requests.

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Appendix A

Table A-1. Available *E. coli* data for Ashley Creek 2668

Water Body	Site Description	Sample ID	Site Code	Date	*E. coli* cfu/100mL
2668	Ashley Ck, upstream of entrance to Current R	361882	2668/0.1	10/19/2023	144.9
		358762		9/14/2023	179.3
		358524		8/3/2023	209.8
		357371		6/27/2023	396.8
		356391		5/2/2023	547.5
		354587		9/22/2022	727.0
		354586		8/22/2022	325.5
		354585		7/27/2022	172.2
		354350		6/9/2022	111.9
		353978		4/7/2022	2,419.6
		312640		10/13/2021	159.7
		312639		9/30/2021	547.5
		312638		9/9/2021	648.8
		310092		8/4/2021	93.3
		310091		7/15/2021	172.6
		290330		7/24/2017	121.1
		245503		9/10/2012	387.3
		245502		8/30/2012	147.0
		245501		8/15/2012	435.2
		245500		7/30/2012	613.1
		245499		7/16/2012	48.8
		245498		7/2/2012	272.3
		245497		6/20/2012	1,203.3
		245496		6/4/2012	2,419.6
		245495		5/21/2012	648.8
		245494		9/26/2011	60.2
		245493		9/12/2011	123.4
		245492		8/29/2011	60.2
		245491		8/15/2011	84.5
		245490		8/1/2011	113.7
		245489		7/18/2011	325.5
		245488		7/5/2011	25.6
		245487		6/20/2011	178.9
		245486		6/6/2011	105.0
		245485		8/17/2010	18.1
		245484		7/20/2010	75.4
		245483		7/13/2010	133.6

Appendix B

Development of *E. coli* Load Duration Curve

Overview

A load duration curve approach was used to develop the *E. coli* TMDL for Ashley Creek. Load duration curves visually display the loading capacity of a water body at all possible flows based on historic flow data and the defined target concentration for each pollutant. For this TMDL, no portion of the loading capacity is assigned to a wasteload allocation. Ten percent of the loading capacity is reserved as an explicit margin of safety. The remaining portion of the loading capacity is allocated to nonpoint sources.

Methodology

Load duration curves are based on a flow duration curve developed using a long-term time series of daily average flows and a numeric water quality target. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same ecological drainage unit. The numeric target for the *E. coli* load duration curve is the whole body contact category A criterion of 126 cfu/100 mL.

For Ashley Creek, flow estimates were area-corrected based on flows measured at the nearby and representative watershed draining into USGS stream gage 07064440 on the Current River at Montauk State Park, MO. Daily discharge data was used from February 2007 to October 2023. Average daily flows were area-corrected based on the proportion of the Ashley Creek watershed to the drainage area of USGS gage 07064440. Gage information and correction factor are listed in Table B-1 below.

The *E. coli* TMDL in Section 7 was developed by converting the whole body contact recreation category A *E. coli* criterion of 126 cfu/100 mL to pounds per day based on the flow duration curve and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day. Despite the varying load, the target concentration is constant at all flow percentiles and reflects the static nature of the water quality standards. The observed data provided in Appendix A are plotted on the load duration curve graph in Section 7 to demonstrate the magnitude of load reductions that are needed to meet the TMDL and attain water quality standards.

Table B-9. Stream Gage Used to Develop the Representative Flow[19]

USGS Gage	Drainage Area (mi^2)	Period of Data	Correction Factor
USGS 07064440 Current River at Montauk State Park, MO	58.8	02/2007-10/2023	0.918087

[19] Flow data that were in provisional status at the time of this report were not used.

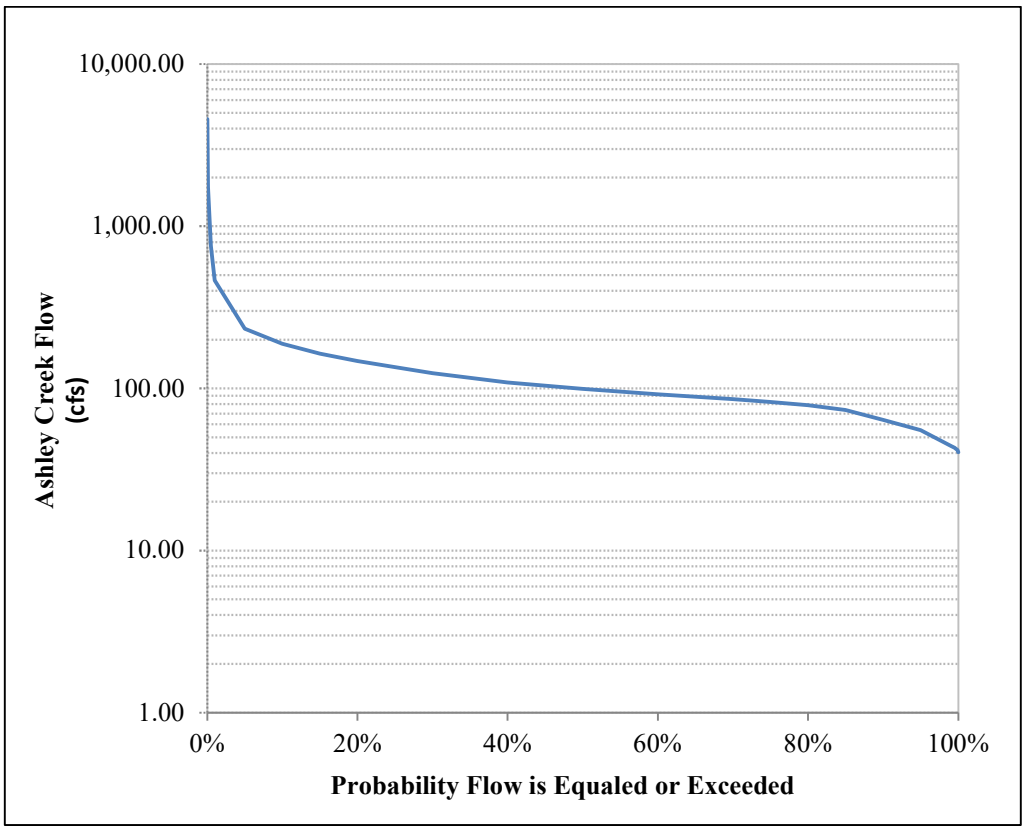

Figure B-1. Ashley Creek Flow Duration Curve